

Method of obtaining 2-mercaptobenzothiazole

Technical Field

5 The invention concerns a method of obtaining 2-mercaptobenzothiazole from a melt of the raw product, wherein the melt contains 2-mercaptobenzothiazole, unreacted raw materials, intermediate products and pitches.

10 Background Art

 2-Mercaptobenzothiazole (hereinafter 2-MBT) is a basic member of the group of benzothiazole accelerators of sulphur vulcanisation of unsaturated rubbers and, simultaneously, it is the decisive basic raw material for industrial
15 production of further important benzothiazole accelerators, like *N*-cyclohexylbenzothiazolesulphene amide, *N-tert*-butylbenzothiazolesulphene amide, *N,N*-dicyclohexylbenzothiazolesulphene amide, *N*-oxydiethylenebenzothiazolesulphene amide and others.

 On an industrial scale, 2-mercaptobenzothiazole is prepared by high-
20 pressure synthesis at high temperature directly from aniline, carbon disulphide and sulphur. In this way a product is obtained, the quality of which does not meet qualitative requirements for application, and in most cases neither for its subsequent processing to sulphene amide accelerators. Therefore, the raw 2-mercaptobenzothiazole must be refined.

25 At present, following techniques are used for industrial purification of 2-mercaptobenzothiazole:

 - pre-precipitation using alkali and mineral acids; the disadvantages are a high content of salts (in the process, there arises at least one mole of inorganic salts per one mole of 2-mercaptobenzothiazole), problems with separation and
30 subsequent disposal of water-insoluble pitchy substances, and also the necessity of distilling off several defined substances present in the raw melt (aniline, benzothiazole, phenylisothiocyanate) using water steam;

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- crystallization of the raw melt in a suitable solvent, like some chlorinated alkanes and alkenes, toluene, nitrobenzene and others. Major disadvantage of the above technique is a high content of 2-mercaptobenzothiazole in mother liquors which arise in the course of crystallization and from which the product is recovered using a relatively demanding process, if the loss in yield is to be lowered. No less important disadvantage of the process is the use of an auxiliary starting substance with all disadvantages associated therewith.

A combination of the above mentioned processes, where 2-mercaptobenzothiazole is extracted by a diluted aqueous alkali solution from the raw melt dissolved in a suitable solvent and subsequently precipitated by a mineral acid, may moderately improve technical-ecological parameters of the product purification process, but it does not solve the above given disadvantages of the involved processes in principle.

The disadvantage of refining the raw product by means of a further solvent is eliminated by using a suitable raw material for 2-mercaptobenzothiazole production. Impurities are removed in such a way that the reaction product is extracted by carbon disulphide or by an emulsion of carbon disulphide in water. This process is described in US 2,090,233 and 3,030,373. US 3,031,073 also describes in detail purification of the melt by an emulsion water/carbon disulphide with addition of a surfactant, but also crystallization of the raw product with 1.5-fold amount of carbon disulphide in an autoclave at 140 °C under pressure during 45 minutes. Moreover, it uses not only carbon disulphide for crystallization, but after thickening the mother liquors from the refinement it tries to utilize the pitchy substances contained therein in further synthesis in such a way that after supplementing the rest of raw materials - aniline and sulphur - the mixture is charged into a pressure reactor. The process is repeated twice on the whole, while quality of the product decreases with further recycling of the pitches. If at least a part of pitches is not withdrawn from the process, their concentration in the system increases, thus causing lowering of qualitative parameters of the product, in consequence of which this is not suitable for the production of sulphene amide accelerators.

The latest solution, which utilizes carbon disulphide refinement of 2-mercaptobenzothiazole, where the filtrate is simultaneously recycled in the

process, is described in DE 4,028,473 (US 5,367,082). A 2-mercaptobenzothiazole melt, obtained in a batch reactor in a conventional manner, is partially cooled by adding carbon disulphide and under the pressure of the resulting hydrogen sulphide it is cooled down to 25 °C. After depressurising the product is filtered and washed with carbon disulphide. Carbon disulphide mother liquors and wash fractions are thickened under vacuum and charged together with the corresponding amount of aniline and sulphur into the reactor. With successive repeating of the above method the yield increases to an average value of 98.7 %, while the content of the active substance and the melting temperature gradually decrease. The authors do not state directly in the examples any removing of a part of mother liquors from the system, but in the invention description they mention that the number of cycles is essentially unlimited, if in each cycle a small part of the mother liquor is removed.

Despite indisputable advantages of the refinement by means of carbon disulphide, also this process has some essential shortcomings:

- necessity to use pressure equipment for crystallization,
- necessity to handle in the process large amounts (even 10-fold with respect to 2-mercaptobenzothiazole) of easily inflammable and toxic carbon disulphide,
- increased energy intensity at distilling off carbon disulphide from the filtrates after crystallization, i.e. at thickening the mother liquors to 10 to 15 % of the original volume.

From FR 2,450,828 (CS 231 971), FR 2,565,977 (US 4,647,669), there is known refinement of 2-mercaptobenzothiazole in aniline. There is stated a possibility of recycling the used recycling medium after the refinement under the condition that one must remove from the system as many impurities as many impurities enter the system together with the reaction product.

The basis of the method described in FR 2,450,828 (CS 231 971) consists in that the raw product melt containing 83.25 % of 2-mercaptobenzothiazole, 2.75 % of aniline, 5 % of benzothiazole and 9 % of pitches is dissolved in 2.5-fold amount of the used ("thickened") aniline (containing 50.7 % of aniline + 1.24 % of benzothiazole + 18.8 % of 2-mercaptobenzothiazole + 29.25 % of side substances from the previous purifying operations. After cooling down the product

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crystallizes, is filtered and several times washed with nearly triple amount of aniline. After removing the wash aniline from the cake containing 2-mercaptobenzothiazole, a product with the content of active substance of 98.9 % and a yield of up to 97.6 %, with respect to the starting 2-mercaptobenzothiazole in the raw product melt. Aniline filtrates are thickened to the starting volume and used in a further purifying operation, the process being repeated with a further batch of melt. To keep an equilibrium between impurities and product, approximately 9 % of mother liquors from primary filtration are withdrawn from the system before mixing with wash aniline and thickening the used aniline to the required volume. From the separated residue, aniline with benzothiazole are distilled off and returned to crystallization; the non-distilling residue (containing pitches and 2-mercaptobenzothiazole) may be removed from the system and partially or completely recycled into the reactor.

The above described refinement method has several disadvantages which make its successful application in practice more difficult or even impossible:

- thickening of crystallization filtrates and wash aniline to the starting volume, i.e. thickening to 1/3, which is energy-intensive and subjecting aniline and substances dissolved in the refining medium to permanent heat stress which may contribute to further formation of pitches,
- washing the filtration cake containing 2-mercaptobenzothiazole by pure aniline leads to dissolution of the product, i.e. to yield losses. Product dissolution creates small channels in the layer of the filtration cake, and inhomogeneous cake causes imperfect washing away of pitch residues from 2-mercaptobenzothiazole and lowering the content of active substance in the product. In these cases it is better to wash the filtration cake in a liquid medium and filter the product again.

- despite the declared removing of 9 % of the filtrate from crystallization benzothiazole will cumulate in the system, because the volatile fractions (aniline and benzothiazole) distilled off from it return back to the refining process, thus making worse the refinement effect,

- complete recycling of the distillation residue into the reactor means, instead of removing it from the process, returning all removed pitches back into

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the system, their accumulation and making the refinement of the raw product impossible.

A method according to FR 2,565,977 (US 4,647,669) is based on the same principle, it differs just by the method of isolation of the pure product and of its
5 drying. These are processes without recycling the used aniline filtrates into the reactor for 2-mercaptobenzothiazole production. It should be sufficient to remove calculable amount of the used filtrate to retain the refining ability of the system, but in fact, this does not work. The description includes also a remark on possible recycling of the distillation residue (obtained from the removed amount of the
10 filtrate) through the reactor, but this possibility is not described in more detail in the examples.

The aim of the present invention is to eliminate the need to remove amine hydrochloride by filtration, by crystallization from petroleum ether, as well as to obtain 2-mercaptobenzothiazole with required quality and yield in a simpler way.

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Disclosure of Invention

The above given aim is achieved by obtaining 2-mercaptobenzothiazole from a melt of the raw product, prepared by the reaction of aniline, carbon
20 disulphide and sulphur, through pressure synthesis, wherein the melt contains 2-mercaptobenzothiazole, unreacted raw materials, intermediate products and pitches, by a method according to the present invention.

For the purpose of the present invention, under the term "liquid phase" we shall understand "mother liquor", "aniline filtrate" or "liquid phase" after separating
25 2-mercaptobenzothiazole by filtration, decantation or centrifuging, always containing aniline.

A melt of the 2-mercaptobenzothiazole raw product, where the melt contains 2-mercaptobenzothiazole, unreacted raw materials, intermediate products and pitches, is prepared by the reaction of aniline, carbon disulphide
30 and sulphur through pressure synthesis. The subject matter of the invention consists in that the 2-mercaptobenzothiazole raw product from the pressure reactor is in the first batch dissolved in an excess (in an approximately double amount) of pure aniline. By cooling down the solution, crystals of 2-

mercaptobenzothiazole are precipitated, which are separated and the liquid phase (filtrate from crystallization; E_K) is used in the next batch. The obtained cake of crystallized (pre-purified) product is processed with a minimum amount of fresh aniline and pure product is separated from the resulting mixture. The
5 obtained liquid phase E_R from final purification is recycled by charging it into the next crystallization.

In the next batch, approximately 1/3 of the liquid phase from crystallization is charged into the reactor for 2-mercaptobenzothiazole preparation and is supplemented, with respect to the content of aniline, by sulphur and carbon
10 disulphide. The obtained melt of the 2-mercaptobenzothiazole raw product is dissolved in the remainder (approximately 2/3) of the liquid phase from crystallization of the preceding batch and is supplemented by the whole amount of liquid phase E_R from final purification, also from the preceding batch, and possibly also by aniline.

15 After crystallization the cake is processed by mixing (dispersing) in pure or regenerated aniline or in a suitable liquid phase. Aniline or suitable liquid phase enter the process in counterflow - they first finally purify the crystallized product in the wash separating operation, then the liquid phase from wash separation enters the raw product crystallization and finally, the liquid phase from the 2-
20 mercaptobenzothiazole raw product crystallization is charged into the reactor for 2-mercaptobenzothiazole synthesis.

After several recycles the composition of the system (reaction medium) becomes steady.

An advantage of the method according to the present invention consists in
25 that recycling of a greater amount of aniline mother liquors from the refinement directly into the reactor (instead of pure aniline) with simultaneous removing of defined amounts of these liquors from the system does not influence negatively the quality of the 2-mercaptobenzothiazole raw product obtained from the reactor, neither the quality of the product obtained by its refinement by aniline or the
30 corresponding liquid phase, and this quality is retained also in the course of multiple repeats at a level of 98 % of active substance, even without necessity to thicken the aniline mother liquors.

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A melt of raw 2-mercaptobenzothiazole obtained directly from the reactor contains besides benzothiazole also further defined chemical compounds, intermediate reaction products, for example thiocarbanilide, anilidobenzothiazole, as well as unreacted raw materials - aniline and sulphur. The actual content of
5 pitches (undefined substances) is lower than 9 %. All stated substances contained in the mother liquors from the refinement may, if returned into the reactor, convert to the product or they maintain chemical equilibrium in favour of the product, suppress side reactions and increase the yield of the process. It is advantageous for the process to recycle them into the reactor in the greatest
10 possible extent.

Working conditions in a batch or tube reactor (temperature, pressure, reaction time) used for preparation of the raw 2-mercaptobenzothiazole from aniline filtrates do not differ from standard conditions of 2-mercaptobenzothiazole synthesis from pure raw materials.

15 It has been found that it is advantageous if at the refinement (final purification) of the raw product the wash separation or washing the filtration cake of 2-mercaptobenzothiazole after crystallization by aniline is replaced by wash separation or washing by a solution of aniline with pure 2-mercaptobenzothiazole. This solution does not dissolve the product and does not cause formation of small
20 channels in the filtration cake - the filtration cake is homogeneous and impurities are washed out over the whole cross-section of the cake. In this way pure product of comparable quality is obtained by a simpler method.

Examples of invention embodiments

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The following examples illustrate in more detail, but do not limit the nature of the invention. The examples describe the course of the process after stabilization of the reaction medium in equilibrium (which is characterized by the stable composition of the streams), which is achieved by several preceding
30 recycles.

Example 1

(without recycling the aniline filtrates)

93.13 g of aniline, 31.42 g of sulphur and 80.67 g of carbon disulphide were charged into a pressure 300 ml reactor. Under conditions usual for this synthesis (220 to 300 °C/6 to 11.1 MPa) a melt of 2-mercaptobenzothiazole raw product was prepared. After reaction the reactor was cooled down to 180 to 200 °C and the reactor content was purged at 200 °C by nitrogen stream, removing the volatile fractions.

155 g of purged melt were obtained (containing 92.3 % of 2-mercaptobenzothiazole, 1.72 % of benzothiazole, 2.14 % of sulphur and 3.84 % of pitches) and 8.9 g of volatile fractions (a mixture of aniline and benzothiazole).

The melt was hot dissolved in 250 g of aniline, 2-mercaptobenzothiazole was crystallized by cooling, and after filtration and drying 114.6 g of the product (i.e. 68.5 % of theoretical yield with respect to aniline charged into the reactor, and 80.1 % yield with respect to the 2-mercaptobenzothiazole content in the raw melt) were obtained, containing 98.4 % of active substance.

Example 2

(After stationary state was reached by multiple recycling of a part of aniline filtrates)

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100 g of aniline filtrate from crystallization (containing 78 % of aniline, 9.5 % of 2-mercaptobenzothiazole) were charged into a pressure 300 ml reactor together with 27 g of sulphur, 67 g of carbon disulphide and 9 g of volatile fractions from the preceding purging of the melt (containing 30 % of aniline and 65 % of benzothiazole). Under conditions usual for this synthesis (220 to 300 °C/6 to 11.1 MPa) a melt of the raw product was prepared. After reaction the reactor was cooled down to 180 to 200 °C and the reactor content was purged at 200 °C by nitrogen stream, removing the volatile fractions.

162.3 g of purged melt were obtained containing 91.0 % of 2-mercaptobenzothiazole, 2.0 % of benzothiazole, 1.5 % of sulphur, 0.9 % of anilidobenzothiazole, 0.1 % of thiocarbanilide, 0.07 % of 2-methylbenzothiazole and 4.43 % of pitches, which melt was dissolved in a mixture of 222 g of liquid

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phase (filtrate) from the preceding crystallization and 200 g of liquid phase (filtrate) from the preceding final purification by wash separation.

After cooling down the crystallized 2-mercaptobenzothiazole product was filtered off, from ~ 295 g of the filtrate 5 % were removed out of the process (waste), 100 g were used as a charge of the next batch in the reactor and the remaining filtrate was used in the next crystallization. Wet aniline cake containing 2-mercaptobenzothiazole was wash separated in 91 g of pure aniline, filtered off, aniline was removed from it by wash separation in hot water and by purging with water steam, and dried. The filtrate from wash separation, consisting in general only of aniline and 2-mercaptobenzothiazole, was used in the next crystallization.

136.9 g of the product containing 98.2 % of active substance, i.e. 91 % yield with respect to 2-mercaptobenzothiazole in the melt, were obtained.

Example 3 - comparative

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The weights were identical with those in Example 1, the amount of obtained purged melt and crystallization conditions were the same as in Example 1, only the wet cake was not wash separated in pure aniline, but was washed with 91 g of aniline directly on the filter and dried. The wash filtrate was returned into the process.

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139.9 g of the product were obtained containing 96.3 % of active substance, which represent 91.2 % yield with respect to 2-mercaptobenzothiazole in the melt.

25 Example 4

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20 g of aniline, 80 g of aniline filtrate from crystallization of the same composition as in Example 1 (78 % of aniline, 9.5 % of 2-mercaptobenzothiazole) were charged into the reactor together with 28 g of sulphur, 71 g of carbon disulphide and 9 g of benzothiazole from purging (volatile fractions). The reactor was heated to working temperature, after reaction it was cooled to 180 to 200 °C, accumulated hydrogen sulphide was released through a pressure control valve and the reactor content was evacuated at 200 °C. At a reduced pressure of 20

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Torr and a temperature of 200 °C, volatile fractions were distilled off from the melt.

161 g of purged melt were obtained containing 92.2 % of 2-mercaptobenzothiazole, 1.8 % of benzothiazole, 1.3 % of sulphur, 0.7 % of anilidobenzothiazole, 0.1 % of thiocarbanilide, 0.05 % of 2-methylbenzothiazole and 3.85 % of unidentified substances. The melt was dissolved in a mixture of 222 g of filtrate from the preceding crystallization and 200 g of filtrate from the preceding refinement. After cooling down the crystallized 2-mercaptobenzothiazole was filtered off, from the filtrate 20 % were removed out of the process, 80 g were separated for the next batch in the reactor and the rest for the next crystallization. Wet aniline product cake was wash separated in 115 g of pure aniline, filtered off, cleared of aniline, and dried. The filtrate from wash separation was used in the next crystallization.

129.2 g of the product with purity of 99.4 % were obtained, i.e. 86.5 % yield with respect to 2-mercaptobenzothiazole in the melt.

Example 5

Into a tube reactor of 5 mm diameter and 15 m length ($V = 295.5$ ml) with a pressure control valve at the end 83 g of aniline filtrate of the composition as in Example 1 and further 22.5 g of sulphur, 56 g of carbon disulphide and 8 g of benzothiazole from purging were charged (169.5 g altogether). The retention time was 1 hour 44 minutes. Under conditions usual for this synthesis (250 to 300 °C/6 to 11.1 MPa) a melt of raw 2-mercaptobenzothiazole was obtained which was after removing hydrogen sulphide purged with nitrogen at 200 °C. After 1 hour and 12 minutes 162 g of purged melt were obtained containing 91.2 % of 2-mercaptobenzothiazole and having further composition similar to that of the raw product from Example 1.

Crystallization and final purification were performed identically as in Example 1. 136.5 g of the product with purity of 98.5 % were obtained, representing 91 % yield with respect to 2-mercaptobenzothiazole in the melt.

Example 6

The weights of raw materials and recycled media in the reactor were identical with those in Example 1, also the amount of obtained purged melt and crystallization conditions were the same.

5 The wet cake was after filtration finally purified by washing with 91 g of saturated solution of pure 2-mercaptobenzothiazole in aniline directly on the filter and dried. The wash filtrate was returned into the process.

146.9 g of the product with purity of 97.8 % were obtained, i.e. 97.3 % yield of the refinement with respect to the entered 2-mercaptobenzothiazole.